

Topic 19: Organic Nitrogen Compounds: Amines, Amides, Amino Acids and Proteins

Students will be assessed on their ability to:

19.1	<p>understand the nomenclature of amides, amines and amino acids and be able to draw their structural, displayed and skeletal formulae</p>																							
<p>The nitrogen atom has a lone pair and three bonds to one or more alkyl groups If there is only one alkyl group, it is a primary amine If there is two, it is secondary If there is three, it is tertiary</p>	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="3" style="text-align: left; padding: 5px;">Amines</th></tr> <tr> <th style="text-align: left; padding: 5px;">NAME</th><th style="text-align: left; padding: 5px;">DISPLAYED FORMULA</th><th style="text-align: left; padding: 5px;">SKELETAL FORMULA</th></tr> </thead> <tbody> <tr> <td style="padding: 5px;">methylamine</td><td style="padding: 5px;"> </td><td style="padding: 5px;"> </td></tr> <tr> <td style="padding: 5px;">ethylamine</td><td style="padding: 5px;"> </td><td style="padding: 5px;"> </td></tr> <tr> <td style="padding: 5px;">propylamine</td><td style="padding: 5px;"> </td><td style="padding: 5px;"> </td></tr> <tr> <td style="padding: 5px;">butylamine</td><td style="padding: 5px;"> </td><td style="padding: 5px;"> </td></tr> <tr> <td style="padding: 5px;">phenylamine</td><td style="padding: 5px;"> </td><td style="padding: 5px;"> </td></tr> </tbody> </table>			Amines			NAME	DISPLAYED FORMULA	SKELETAL FORMULA	methylamine			ethylamine			propylamine			butylamine			phenylamine		
Amines																								
NAME	DISPLAYED FORMULA	SKELETAL FORMULA																						
methylamine																								
ethylamine																								
propylamine																								
butylamine																								
phenylamine																								
<p>Amines are derivatives of ammonia where one or more of the hydrogen atoms is replaced by an organic group (alkyl or aryl) If the R group is an alkyl group (methyl, ethyl, etc) then it is an <i>aliphatic amine</i> If R is an aryl group (benzene ring or phenyl) then it is an <i>aromatic amine</i></p>			<p>Amides are formed from the condensation reaction of carboxylic acids or acyl chlorides with ammonia or amines</p> $\begin{array}{c} \text{O} \\ \parallel \\ \text{R}-\text{C}-\text{N}-\text{R}' \\ \\ \text{R}'' \end{array}$ <p>Have a general structure of RCONR_2 Where R' and R'' are both hydrogen atoms</p>																					
<p>$\begin{array}{c} \text{R}-\ddot{\text{N}}-\text{H} \\ \\ \text{H} \end{array}$ PRIMARY AMINE</p> <p>$\begin{array}{c} \text{R}-\ddot{\text{N}}-\text{H} \\ \\ \text{R} \end{array}$ SECONDARY AMINE</p> <p>$\begin{array}{c} \text{R}-\ddot{\text{N}}-\text{R} \\ \\ \text{R} \end{array}$ TERTIARY AMINE</p>			<p> Primary amide Nitrogen attached to one carbon</p> <p> Secondary amide Nitrogen attached to two carbons</p> <p> Tertiary amide Nitrogen attached to three carbons</p>																					
<p>Common name: alkyl + amine Eg: Propylamine IUPAC name: amino + alkane Eg: Aminoethane</p>			<p>For primary amides: alkan + amide Eg: propanamide</p> <p>For secondary amides: alkyl chain that is attached to N atom is prefixed with N- Eg: $\text{CH}_3\text{CONH}(\text{C}_3\text{H}_7) \rightarrow \text{N-propylethanamide}$</p> <p>For tertiary amides: Eg: $\text{CH}_3\text{CONCH}_3(\text{C}_3\text{H}_7) \rightarrow \text{N-methyl-N-propylethanamide}$</p>																					

	<p>Amino acids</p> <ul style="list-style-type: none"> - Are organic compounds that contain two functional groups: <ul style="list-style-type: none"> o A basic amino (-NH₂) group o An acidic carboxylic acid (-COOH) group - Are amphoteric due to presence of both a basic and acidic group in amino acids - Hence, can act as both acids and bases - General structural formula of amino acids: <div style="text-align: center;"> <p>The diagram shows three general structural formulas of amino acids. Each consists of a central carbon atom bonded to an amino group (NH₂), a carboxylate group (COO⁻), and two hydrogen atoms. - In Aspartic Acid, the R group is -CH₂COOH, labeled as 'R GROUP = ACIDIC'. - In Serine, the R group is -CH₂OH, labeled as 'R GROUP = BASIC'. - In Alanine, the R group is -CH₃, labeled as 'R GROUP = NEUTRAL'.</p> </div> <p>Copyright © Save My Exams. All Rights Reserved</p>
19.2	<p>understand the reactions of primary aliphatic amines (using butylamine as an example) and aromatic amines (using phenylamine as an example) with:</p> <ol style="list-style-type: none"> water to form an alkaline solution acids to form salts halogenoalkanes ethanoyl chloride copper(II) ions to form a complex ion
i	<p>Reactions with water</p> <ul style="list-style-type: none"> - To form <i>alkaline solutions</i> Eg: methylamine + water \rightleftharpoons methylammonium ion + hydroxide ion $\text{CH}_3\text{NH}_2 + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{NH}_3^+ + \text{OH}^-$ - Phenylamine is only slightly soluble in water - Reaction does not readily occur with phenylamine because the lone pair on nitrogen is incorporated into the delocalized electrons in the benzene ring which makes it less available to donate the electrons to the hydrogen of water
ii	<p>Reactions with acids to form salts</p> <ul style="list-style-type: none"> - All react with strong acids to <i>form ionic ammonium salts</i> - Eg: butylamine + hydrochloric acid \rightarrow butylammonium chloride - Eg: phenylamine + acid \rightarrow phenylammonium chloride
iii	<p>Reactions with Halogenoalkanes</p> <p>Type: Substitution</p> <p>Mechanism: nucleophilic substitution (shown in 10.9ii)</p> <div style="text-align: center;"> <p>The diagram illustrates the mechanism of nucleophilic substitution (SN2) between diethylamine and bromomethane. 1. $\text{CH}_3\text{CH}_2\text{NH}_2$ attacks the electrophilic carbon of CH_3Br, forming a tetrahedral intermediate: $\text{H}_3\text{C}-\text{CH}_2-\text{NH}_2^+-\text{CH}_2-\text{CH}_3 \quad \text{Br}^-$. 2. A hydrogen bond forms between the lone pair on the nitrogen and the adjacent alpha-hydrogen, facilitating the loss of a proton to form the final products: $\text{H}_3\text{C}-\text{CH}_2-\text{NH}-\text{CH}_2-\text{CH}_3$ (Diethylamine) and $\text{CH}_3\text{CH}_2\text{NH}_3\text{Br}$.</p> </div> <p>General equation: R'NH₂ + R''X → R'NHR'' + HX</p> <ul style="list-style-type: none"> • Eg: phenylamine + chloroethane \rightarrow secondary amine + HCl $\text{C}_6\text{H}_5\text{NH}_2 + \text{CH}_3\text{CH}_2\text{Cl} \rightarrow \text{C}_6\text{H}_5\text{NHCH}_2\text{CH}_3 + \text{HCl}$ • Eg: butylamine + chloroethane \rightarrow secondary amine + HCl

$$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2 + \text{CH}_3\text{CH}_2\text{Cl} \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NHCH}_2\text{CH}_3 + \text{HCl}$$

	<p><i>Further reaction</i></p> <p>The secondary amine formed still contains an electron-rich N atom so can react with more halogenoalkane to form a tertiary amine which can also react with more halogenoalkane to form a quaternary ammonium salt</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Where RX is the haloalkane</p> </div> <div style="text-align: center;"> </div> </div>
iv	<p>Reactions with Ethanoyl Chloride</p> <p>Type: Condensation (addition-elimination)</p> <p>Eg: phenylamine + ethanoyl chloride \rightarrow N-phenylethanamide + HCl</p> $\text{C}_6\text{H}_5\text{NH}_2 + \text{CH}_3\text{COCl} \rightarrow \text{CH}_3\text{CONHC}_6\text{H}_5 + \text{HCl}$ <p>Change in functional gp. from amine to amide</p> <p>Conditions: Room temp.</p> <p>!Acyl chlorides react with primary amines (RNH_2), forming an N-substituted amide and hydrogen chloride gas (misty fumes)</p>
v	<p>Reactions with Copper(II) ions</p> <ul style="list-style-type: none"> - The lone pair of electrons on the nitrogen <i>enable amines to act as ligands</i> and form dative covalent bonds into transition metal ions - Form coloured complex ions <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>Formation of the pale blue precipitate (deprotonation)</p> $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 2\text{CH}_3\text{CH}_2\text{NH}_2 \rightarrow [\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2] + 2\text{CH}_3\text{CH}_2\text{NH}_3^+$ <p>Light blue solution pale blue precipitate</p> </div> <div style="width: 45%;"> <p>Formation of the deep blue solution (ligand exchange)</p> $[\text{Cu}(\text{H}_2\text{O})_4(\text{OH})_2] + 4\text{CH}_3\text{CH}_2\text{NH}_2 \rightarrow [\text{Cu}(\text{CH}_3\text{CH}_2\text{NH}_2)_4(\text{H}_2\text{O})_2]^{2+} + 2\text{H}_2\text{O} + 2\text{OH}^-$ <p>Pale blue precipitate Deep blue solution</p> </div> </div>

19.3	<p>understand that amines are miscible with water as a result of hydrogen bonding, and the reasons for the difference in basicity between ammonia, primary aliphatic amines and primary aromatic amines</p>
	<p>Solubility of Amines</p> <ul style="list-style-type: none"> - The first few members of the homologous series of primary aliphatic amines are miscible with water - But, as the hydrocarbon part of the molecule increases, the solubility decreases - They can dissolve in water as the N atom can use its lone pair to form a dative bond with the H atom of water (i.e. they can form hydrogen bonds with water) - Phenylamine is only slightly soluble in water <p>Basicity of Amines</p> <ul style="list-style-type: none"> - Primary aliphatic amines act as Bronsted-Lowry bases because the lone pair of electrons on the N atom is readily available for forming a dative covalent bond with a H^+ ion and so they can accept a proton - Factors that may affect the basicity of amines include: <ol style="list-style-type: none"> 1. Positive inductive effect 2. Delocalisation <p>Secondary amines are stronger bases than primary amines because they have more alkyl groups which result in more electron density being pushed onto the N atom, causing more positive inductive effect (as the inductive effect of alkyl groups is greater than that of H atoms)</p> <p>Primary aliphatic amines are stronger bases than ammonia as there is greater electron density on the nitrogen atom. This is due to the alkyl groups being electron-releasing and pushing electrons towards the nitrogen atom (positive inductive effect)</p> <p>Ammonia does not have electron-donating groups to cause positive inductive effect, but it does not have aromatic rings to cause delocalization of nitrogen's lone pair either</p> <p>Primary aromatic amines such as phenylamine do not form basic solutions because the lone pair of electrons on the nitrogen is delocalised in the benzene ring and so is less able to accept protons (and form dative bond with H^+)</p>

19.4	<p>understand, in terms of reagents and general reaction conditions, the preparation of primary aliphatic amines:</p> <ol style="list-style-type: none"> from halogenoalkanes by the reduction of nitriles
i	<p>Preparation from Halogenoalkanes</p> <p>Nucleophile: NH_3 Mechanism: nucleophilic substitution (shown in 10.9ii)</p> $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} + 2\text{NH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2 + \text{NH}_4\text{Br}$ <p>Change in functional gp. Primary Halogenoalkane Primary Amine</p> <p>Reagents: excess NH_3 in ethanol Conditions: ethanolic, heat under pressure in a sealed tube</p> <p>Further substitution reactions can occur between the halogenoalkane and the amines formed leading to a lower yield of the amine (secondary amines can form)</p>

	<p>To produce a high yield of primary amine, <u>ammonia is used in excess</u> which limits further reactions</p> <p>ii</p> <p>A primary halogenoalkane reacts with ammonia to form a primary amine. Mechanism is as follows:</p> <p>Lone pair on ammonia attacks partially positive carbon</p> <p>C-X bond breaks heterolytically</p> <p>Another NH₃ acts as a base and removes a proton</p> <p>N-H bond breaks heterolytically</p>
ii	<p>Preparation from Nitriles</p> <p>Type: Reduction</p> <p>Reducing Agent: LiAlH₄ in dry ether (OR with H₂ and Ni catalyst)</p> $\text{CH}_3\text{CH}_2\text{CN} + 4[\text{H}] \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$ <p>Change in functional gp. Nitriles Primary Amine</p> <p>Conditions: in dry ether (to ensure no water is present) !Usually followed by hydrolysis with dilute acid</p>
19.5	<p>know the preparation of aromatic amines by the reduction of aromatic nitro-compounds using tin and concentrated hydrochloric acid</p> <p>Preparation of Aromatic Amines (Phenylamine)</p> <p>Type: Reduction (of nitrobenzene)</p> <p>Reducing Agent: Sn (Tin) & HCl(aq)</p> $\text{C}_6\text{H}_5\text{NO}_2 + 6[\text{H}] \rightarrow \text{C}_6\text{H}_5\text{NH}_2 + 2\text{H}_2\text{O}$ <p>Change in functional gp. Benzene Aromatic Amine</p> <p>Conditions: mixed in conc. HCl(aq) and heat under reflux</p> <p>Phenylamine is basic so will react with the acid to form phenylammonium ion which can be converted into phenylamine by adding an alkali like NaOH</p> <p>NITROBENZENE STAGE 1 PHENYLAMMONIUM ION STAGE 2 PHENYLAMINE</p>

	<p>Purification of Phenylamine</p> <ul style="list-style-type: none"> - The crude phenylamine product undergoes steam distillation to produce a cloudy distillate - Sodium chloride is added to the distillate before the mixture is added to a separating funnel - Ether is added to the separating funnel resulting in an aqueous layer at the bottom and an organic layer, containing the phenylamine, on the top <ul style="list-style-type: none"> o The sodium chloride aids separation by increasing the polarity of the aqueous layer causing the phenylamine to "salt out" into the organic layer - The aqueous layer is discarded and the organic layer is distilled <ul style="list-style-type: none"> o The ether will boil off easily and is discarded o The phenylamine fraction that boils off at 180-185°C is retained and can have its boiling point tested to check the purity of the product
19.6	be able to describe the reaction of aromatic amines with nitrous acid to form benzenediazonium ions, followed by a coupling reaction with phenol to form a dye
	<p>Reaction of Aromatic Amines</p> <p><u>Formation of Azo Dyes</u></p> <ul style="list-style-type: none"> • Azo (or diazonium) compounds are organic compounds that have an $R_1-N=N-R_2$ group • They are often used as dyes, pigments and colourings and are formed in a coupling reaction between the diazonium ion and an alkaline solution of phenol <p>Coupling of benzenediazonium chloride with phenol in NaOH</p> <p>Step 1: Formation of Nitrous acid</p> $NaNO_2 + HCl \longrightarrow HNO_2 + NaCl$ <p style="text-align: center;">NITROUS ACID</p> <div style="border: 1px solid black; padding: 5px; margin-left: 20px;"> HNO₂ is made in situ from NaNO₂/HCl </div> <p>If temp is above 10°C, the diazonium ion will decompose to form phenol and nitrogen If temp is below 0°C, reaction would be too slow</p> <p>Step 2: Reaction of Phenylamine with Nitrous Acid forming Diazonium ions Condition: Dilute acid and Temperature should be between 0 and 10°C using ice</p> $\text{phenylamine} + HNO_2(\text{aq}) + HCl(\text{aq}) \longrightarrow \text{benzenediazonium ion}$ <p>Step 3: Reaction of Diazonium ions with Phenols forming Azo Dyes Condition: alkaline conditions (NaOH)</p> $\text{C}_6\text{H}_5\text{N}_2^+ + \text{C}_6\text{H}_5\text{OH} \xrightarrow{\text{NaOH}} \text{4-hydroxyazobenzene}$ $\text{C}_6\text{H}_5\text{N}_2^+ + \text{C}_6\text{H}_5\text{OH} \rightarrow \text{C}_6\text{H}_5\text{N}_2\text{C}_6\text{H}_4\text{OH} + \text{HCl}$

19.7	understand that amides can be prepared from acyl chlorides
Formation of Amides from acyl chlorides	
Type: Condensation reaction (nucleophilic addition-elimination)	
Condition: Room temp.	
Amides can be prepared from the condensation reaction between an acyl chloride and ammonia or amine	
<ol style="list-style-type: none"> Acyl chlorides react with primary amines (RNH_2), forming a N-substituted amide and hydrogen chloride gas (misty fumes) Acyl chlorides react with secondary amines (R_2NH), forming a N,N-disubstituted amide and hydrogen chloride gas (misty fumes) Acyl chlorides react with ammonia (NH_3), forming a non-substituted amide 	
<p>The diagram illustrates three nucleophilic addition-elimination reactions:</p> <ul style="list-style-type: none"> Top reaction: Propanooyl chloride reacts with methylamine (primary amine) to form methyl propanamide (substituted amide) and HCl. Middle reaction: Propanooyl chloride reacts with dimethylamine (secondary amine) to form dimethyl propanamide (substituted amide) and HCl. Bottom reaction: A general acyl chloride ($\text{R}-\text{C}(=\text{O})-\text{Cl}$) reacts with two molecules of ammonia (2NH_3) to produce an amide ($\text{R}-\text{C}(=\text{O})-\text{NH}_2$) and ammonium chloride ($[\text{NH}_4]^+\text{Cl}^-$). 	
<p>Addition-Elimination Mechanism (You may not need to know)</p> <p>The mechanism consists of two steps:</p> <ol style="list-style-type: none"> Step 1: Nucleophilic Addition - Ammonia (NH_3) attacks the electrophilic carbonyl carbon of the acyl chloride ($\text{CH}_3\text{CH}_2-\text{C}(=\text{O})-\text{Cl}$). The nitrogen atom of ammonia forms a C-N bond, and the oxygen of the carbonyl group forms a C=O double bond. A chloride ion (Cl^-) is released. Step 2: Elimination - The resulting intermediate, a protonated amide ($\text{H}-\text{N}^+-\text{CH}_3$), loses a proton to form the neutral amide product (methyl propanamide) and releases HCl. 	
<p>Paracetamol is made by the reaction of an aromatic amine with an acyl chloride to produce an amide</p> <p>The synthesis of paracetamol is shown as follows:</p> $\text{HO}-\text{C}_6\text{H}_4-\text{NH}_2 + \text{CH}_3-\text{C}(=\text{O})-\text{Cl} \rightarrow \text{HO}-\text{C}_6\text{H}_4-\text{NH}-\text{C}(=\text{O})-\text{CH}_3$ <p>Paracetamol</p>	

<p>19.8</p> <p>be able to describe:</p> <ul style="list-style-type: none"> i condensation polymerisation for the formation of polyamides such as nylon and proteins ii addition polymerisation, including poly(propenamide) and poly(ethenol)
<p>i Condensation polymerization</p> <ul style="list-style-type: none"> - Condensation polymerisation has been covered in 15.16 - Defined as "<i>a reaction where two different monomers join together to form a long chain polymer with the elimination of a small molecule (usually water or hydrogen chloride)</i>" - Most common types of condensation polymers are polyesters and polyamides which involve the formation of an ester or an amide linkage - Condensation polymers can be formed by: <ul style="list-style-type: none"> Dicarboxylic acids and diols Dicarboxylic acids and diamines Amino acids
<p>Polyesters</p> <ul style="list-style-type: none"> - Has been covered in 15.16 - Has an ester linkage (-COO-) - Formed by the reaction between dicarboxylic acid and diol monomers - Can also be formed by hydroxycarboxylic acids monomers (contain an -OH group at one end while the other has a -COOH group) <div style="text-align: center;"> <p>The diagram shows the reaction between a dicarboxylic acid monomer, HO—(CH₂)₃—C(=O)Cl, and a diol monomer, —O—(CH₂)₃—C(=O)O—(CH₂)₃—C(=O)O—(CH₂)₃—C(=O)Cl. An arrow points to the right, indicating the formation of a repeating unit: —O—(CH₂)₃—C(=O)O—(CH₂)₃—C(=O)O—(CH₂)₃—C(=O)O—(CH₂)₃—C(=O)Cl. Below this structure, the text "3 repeating units" is written.</p> </div>
<p>Polyamides</p> <ul style="list-style-type: none"> - Has an amide linkage (-CONH-) - Formed by reaction between diacyl dichlorides and diamine - Formed by reaction between dicarboxylic acid and diamine
<p>Kevlar- a common polyamide</p> <div style="text-align: center;"> <p>The diagram shows the reaction between n molecules of terephthalic acid, HO₂C—C₆H₄—CO₂H, and n molecules of 4-aminobiphenyl, H₂N—C₆H₄—NH₂. An arrow points to the right, indicating the formation of a repeating unit: [N—C₆H₄—NH—C(=O)—C₆H₄—NH—C(=O)]_n. Above the brackets, the reaction is labeled with '+ 2n-1 H₂O'.</p> </div> <p>Kevlar is a strong and flexible polymer material with fire resistance properties</p>
<p>Amino Acids</p> <ul style="list-style-type: none"> - Proteins are basically polymers made up of amino acid monomers - Amino acids have an aminocarboxylic acid structure - Their properties are governed by a branching side group - the R group <div style="display: flex; align-items: center;"> <div style="flex-grow: 1;"> <p>The diagram shows the general structure of an amino acid: AMINO GROUP (H₂N—C—R) and CARBOXYL GROUP (C(=O)—C—OH). The SIDE CHAIN (R) is highlighted with a blue dashed box. Below the structure, a box states: "THE R SIDE CHAIN IS DIFFERENT FOR EACH AMINO ACID. THE 20 NATURALLY OCCURRING AMINO ACIDS HAVE UNIQUE R GROUPS".</p> </div> <div style="margin-left: 20px;"> <p>2 AMINO ACIDS REACT TOGETHER TO FORM A DIPEPTIDE</p> <p>The diagram shows the condensation reaction of two amino acids to form a dipeptide. On the left, the structure of an amino acid is shown: H₂N—C(R)—COOH. An arrow points to the right, labeled with "-H₂O". On the right, the structure of a dipeptide is shown: H₂N—C(R)—C(=O)—NH—C(R)—COOH. A box labeled "AMIDE/PEPTIDE LINK IN THE DIPEPTIDE" points to the central amide bond (C=O—NH—).</p> </div> </div>

ii	<p>Addition polymerization</p> <ul style="list-style-type: none"> - Addition polymerisation has been covered in 5.7 - Defined as "a reaction where small chain monomers are converted into long chain polymers without the elimination of any small atoms or molecules" - They are formed using unsaturated monomers (they have C=C bonds) joined together to form polymers such as poly(alkenes) - Poly(alkenes) are chemically inert due to the strong C-C and C-H bonds and non-polar nature of the bonds which makes them non-biodegradable <div style="border: 1px solid black; padding: 10px;"> <p>It is best to first draw out the monomer with groups of atoms arranged around the double bond</p> <p>e.g. For propenamide</p> <p>Poly(ethenol)</p> <p>The addition polymer poly(ethenol) has good solubility in water because it can form many strong hydrogen bonds with water. This makes it a useful polymer for uses such as soluble laundry bags and liquid detergent capsules (liquitabs).</p> </div>
19.9	<p>be able to draw the structural formulae of the repeat units of the polymers in 19.8</p>
i	<p><i>Condensation Polymers</i></p>
	<p>Nylon</p>
	<p>Nylon 6,6 - a common polyamide</p>
	<p>The 6,6 stands for 6 carbons in each of the monomers. Different length carbon chains produce different polyamides</p>
	<p>Proteins</p>
ii	<p><i>Addition Polymers</i></p>

	<p>Poly(propenamide)</p>
	<p>Poly(ethanol)</p>
	<p>The addition polymer poly(ethanol) has good solubility in water because it can form many strong hydrogen bonds with water</p> <p>This makes it a useful polymer for uses such as soluble laundry bags and liquid detergent capsules (liquitabs)</p>
19.10	be able to comment on the physical properties of polyamides and the solubility in water of the addition polymer poly(ethanol) in terms of hydrogen bonding, including soluble laundry bags or liquid-detergent capsules (liquitabs)
	<p>Properties of polyamides</p> <ul style="list-style-type: none"> Most polyamides (nylons) tend to be semi-crystalline They are generally very tough with good thermal and chemical resistance Polyamides tend to absorb moisture from their surroundings <ul style="list-style-type: none"> This absorption increases until equilibrium is reached The impact resistance and flexibility of polyamides increases with water content whilst strength and stiffness decrease The strong bonds in polyamides make the polyamide chains strong allowing them to be made into strong fibres for clothing <ul style="list-style-type: none"> E.g. Kevlar shown above Polyamide film (cling film) is used in food packaging due to its toughness and the fact it prevents gas molecules from passing through Polyamide film is also used for 'Boil in the bag' foods due to its high-temperature resistance
19.11	be able to describe experiments to investigate the characteristic behaviour of amino acids limited to: <ol style="list-style-type: none"> acidity and basicity and the formation of zwitterions effect of aqueous solutions on plane-polarised monochromatic light formation of peptide bonds by condensation polymerisation
i	<p>Acidity and basicity</p> <ul style="list-style-type: none"> The amine group is basic (so will react with acids) and the carboxylic acid group is acidic (so will react with bases) However, they can also interact intramolecularly (within themselves) to form a zwitterion

	<ul style="list-style-type: none"> - A zwitterion is an ion with both a positive (-NH₃⁺) and a negative (-COO⁻) charge - Because of these charges in a zwitterion, there are strong intermolecular forces of attraction between amino acids <ul style="list-style-type: none"> o Amino acids are therefore soluble crystalline solids <p>Formation of zwitterions (isoelectric point)</p> <ul style="list-style-type: none"> - Amino acids act as weak buffers and will only gradually change pH if small amounts of acid or alkali are added to the amino acids <p>Lysine is a zwitterion as a solid</p>
ii	<p>Optical Activity</p> <p>All amino acids, except glycine, are chiral because there are four different groups around the C atom</p> <p>Aqueous solutions of the enantiomers rotate plane-polarised light</p> <p>If an amino acid is synthesised in the lab, a racemic mixture is formed</p>
iii	<p>Formation of peptide bonds (by condensation polymerization)</p>
19.12	<p>CORE PRACTICAL 15</p> <p>Analysis of some inorganic and organic unknowns.</p> <p>Further suggested practicals:</p> <ul style="list-style-type: none"> i carry out some of the reactions of amines from 19.2 i, ii and v ii prepare an azo dye from 19.6 iii carry out reactions of amino acids from 19.11 i iv prepare nylon-6.6 or 6.10 from 19.8